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Experimental studies on seed production of tropical grasses in Kenya. 5. The effect of time of nitrogen top dressing on seed crops of *Setaria sphacelata* cv. Nandi

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Summary

The effect of time of nitrogen top dressing on early-season and late-season seed crops of *Setaria sphacelata* cv. Nandi was studied in four experiments during the period 1967—1971.

Nitrogen gave the best results when applied as soon as possible after the onset of the rainy season. A delay of four weeks decreased yield of Pure Germinating Seed (PGS) by more than 60 %. Total yield of herbage dry matter and head numbers were also negatively affected but to a lesser extent. The main seed yield component reduced by late applied nitrogen was the seed set per head.

In the late-season crops, a delay in top dressing of two weeks after the earliest possible date proved beneficial in two out of three years.

Introduction

Nitrogen (N) being the major factor determining seed yield in *Setaria sphacelata* cv. Nandi (Boonman, 1972), it is imperative to assess the optimal time of aplication in relation to stage of crop development and climatic conditions.

The present study describes 4 experiments undertaken to investigate the effect of time of N application both at fixed and varied dates of cleaning cut. Exp. 1 was designed to determine the effect of split application. It was found that late applied N had no beneficial effect, and this raised the question of whether this was due to season or to the advanced stage of growth at the time of application. To clarify the issue, the following experiments were subsequently initiated:
— Exp. 2: data of cleaning cut (C) was varied, N being applied directly after cutting;
— Exp. 3 and 4: date of cleaning cut was fixed but time of N application (T) was varied.

The latter two experiments are very relevant to current commercial practice. Seed fields are normally cut for hay or grazed in the dry season, December—March, so that little herbage is present at the onset of the rains. Nevertheless, many seed growers do not top dress until May or even later, since other farm work receives greater priority. Quite apart from the effect this delay has on the yield of the early-season crop, less of the rainy season is left for the subsequent development of a late-season seed crop.

If, however, the first crop has been taken early and a second crop is envisaged, the question again arises as to when N should be applied to ensure maximum yield. Ideally, the seed grower should have sufficient time at his disposal to utilize the herbage left over from the first crop before top dressing is required for the second crop.

Only post-establishment crops are considered in this study as no nitrogen is normally applied to the establishment crop.

Materials and methods

Exp. 1 (1967) was laid out in a seed field planted in 1964 with *Setaria sphacelata* cv. Nandi I. The lay-out was a replicated 4 $\times$ 2 factorial, with 4 levels of N applied either as a single dressing on 17 April, 2 weeks after the onset of the rains, or as a split dressing with half on 17 April and half on 6 June (Table 1). The latter date was 1 week after IHE (Initial Head Emergence, 5-10 heads per m^2) and 6 weeks before the seed harvest on 15 July.

Exp. 2 (1970) was carried out in a seed field planted in 1969 with Nandi II. Treatments consisted of different dates of cleaning cut, spaced 2 weeks apart (Table 2). A top dressing with 100 kg N immediately followed the cleaning cut. The seed harvest was carried out 6 weeks after IHE in the treatment concerned. On the date of harvest all herbage was removed and another top dressing at 100 kg N per ha was applied.

Exp. 3 (1969 and 1970) was laid out in a seed field planted in 1968 with Nandi II. At equal intervals 100 kg N per ha were applied, the base date being the day on which all treatments received the cleaning cut (Table 3). A control with no-N was included. All treatments were harvested for seed on the same day.

Exp. 4 (1971) was situated in the same field as Exp. 2. The field was burnt on 10 February and the rains broke in early April. Table 4 shows the dates when 100 kg N per ha were applied to the treatments, which were arranged in a latin square design.

All experiments were in 4-5 replicates on fields in which the rows were spaced 80-90 cm apart. N was applied in the form of ammonium sulphate nitrate. Single superphosphate was applied annually. Harvesting and sampling were carried out as described previously (Boonman, 1972). For monthly rainfall data see Boonman (1972).

With the exception of 1967 and 1971, when the rains had a clear-cut beginning after rainless dry seasons, determination of the base date for treatments in the other years with wet 'dry' seasons was slightly arbitrary. The harvest date of the early-season crop functioned simultaneously as the base date for the late-season crop.

Results

N increased head number, head length and yield of clean seed significantly in Exp. 1, but the effect on yield of Pure Germinating Seed (PGS) was not significant (Table 1). Splitting the application had a significant, negative effect on yields. $N_{34/0}$ outyielded $N_{17/17}$ as well as $N_{34/34}$. Similarly, $N_{68/0}$ outyielded $N_{34/34}$ as well as $N_{68/68}$.

Split application had no significant effect on head number. This in fact means that the second half of the application had a similar effect in raising head numbers as the first half, the difference being that the second half increased the number of late emerging heads. As a result, overall mean head length was reduced by split application, while the significant interaction indicates that the response to increased N was better in the single application. Treatments had no effect on 1000-grain weight or percentage of PGS.

Table 1. The effect of split application of nitrogen on a seed crop of Nandi I; cleaning cut 17 April, harvest 15 July 1967. Experiment 1.

Nitrogen (kg/ha)		Yield of clean seed (kg/ha)	PGS (%)	Yield of PGS (kg/ha)	Head number per m²	Head length (cm)	1000-grain weight (mg)
17 April	6 June						
34	—	128	38	49	240	13.7	380
68	—	145	39	57	270	13.7	370
102	—	162	33	54	330	14.3	310
136	—	161	39	63	300	16.5	360
17	17	110	39	43	200	12.1	370
34	34	109	38	41	210	12.5	390
51	51	141	39	55	280	14.5	350
68	68	139	36	50	310	12.5	410
C.V. %		13.0		22.6	14.4	4.9	35.1
Source of variation							
Nitrogen		**		NS	*	*	NS
Split		**		*	NS	**	NS
Nitrogen × Split		NS		NS	NS	**	NS

*P <0.05; **P <0.01; NS = not significant.

By delaying cleaning cut (C) and simultaneous top dressing, by 2 and 4 weeks, yield of PGS declined by 19 and 65 %, respectively, in the first crop of Exp. 2 (Table 2). The main yield component responsible for this decline was the percentage of PGS which was highest at C_1, whereas yield of clean seed and head number were highest at C_2. Yield of dry matter also decreased. The apparently better growing conditions in the early part of the season were also reflected in the intervals between C and IHE. These intervals increased from 9 to 11 weeks as C was delayed. The 1000-grain weight increased also. In the unclean seed the weight percentage of spikelets with bunt *(Tilletia echinosperma)* was more than doubled at C_6 compared to C_1.

In the second crop of Exp. 2, however, yield of clean seed, yield and percentage of PGS were much higher at C_2, 16 July, than at C_1, 3 July (Table 2). Later cuts resulted in a further decline of yield, and the last cut did not produce a crop at all since its IHE fell right in the dry season. Except at the last cut, intervals between cleaning cut and IHE were 11 weeks. The higher degree of shedding in the later cuts may indicate that seed maturation was more rapid as the dry season came nearer. Both the 1000-grain weight and the weight percentage of bunted spikelets in the unclean seed reached a maximum at the third cut. The 1000-grain weights of the second crop were higher than those of the first.

In Exp. 3 and 4, date of cleaning cut was not varied, so that effects of crop stage and time of application were confounded. In Exp. 3 (1969 and 1970), herbage was cut back in all treatments on the same base date (T_1). In Exp. 4 (1971), the field was burnt during the dry season and the base date (T_1) immediately followed the very sudden onset of the rains in that year. Since date of IHE in the first crops was not affected by T, treatments were all harvested on the same day.

In the early-season crops a delay in top dressing of only two weeks caused a decline in yield of PGS of 10, 58 and 46 % in 1969, 1970 and 1971, respectively. The corresponding decreases caused by a delay of 4 weeks were 65, 76 and 62 % (Table 3 and 4). In Exp. 3, yields at T_4 were nearly as low or even lower than at no-N (Table 3). Yields

Table 2. The effect of delayed cleaning cut and top dressing on seed crops of Nandi II, 1970. Experiment 2.

Date of cleaning cut and N top dressing	Interval till IHE (weeks)	Date of seed harvest	Yield of clean seed (kg/ha)	PGS (%)	Yield of PGS (kg/ha)	Yield of dry matter (tons/ha)	Head number per m²	Heading tillers (%)	1000-grain weight (mg)	Bunt in unclean seed (%)	Seed shedding (1-5; 5 = no shedding)
First crop											
20 March	9	3 July	74	11.4	8.4	11.6	137	41	250	20	NR
3 April	9	16 July	86	7.9	6.8	10.9	150	43	260	25	
17 April	9	30 July	75	3.9	2.9	9.1	95	19	290	26	
1 May	10	19 August	57	4.2	2.4	9.1	72	14	290	37	
15 May	10	5 September	62	1.9	1.2	8.4	76	19	310	40	
29 May	11	28 September	60	4.2	2.5	8.6	76	20	350	46	
LSD (0.05)			12		3.3	1.3	19		40		
LSD (0.01)			17		4.1	1.8	26		60		
Second crop											
3 July	11	28 October	95	8.7	8.3	NR	132	NR	260	27	4.4
16 July	11	11 November	139	22.7	31.5		174		380	25	4.2
30 July	11	25 November	56	11.8	6.6		113		460	31	4.1
19 August	11	9 December	40	9.5	3.8		79		420	27	3.9
5 September	11	23 December	12	5.0	0.6		40		380	19	4.1
28 September	12	(no crop)									
LSD (0.05)			36		12.2		35		80		0.3
LSD (0.01)			49		17.7		49		110		0.4

NR = no record taken.

Table 3. The effect of time of nitrogen application on yields in seed crops of Nandi II in 1969 and 1970. Experiment 3.

1st crop 1969 (cleaning cut 14 April, harvest 1 August)			1st crop 1970 (cleaning cut 30 March, harvest 13 July)		
nitrogen (date)	yield of PGS (kg/ha)	yield of dry matter (tons/ha)	nitrogen (date)	yield of PGS (kg/ha)	yield of dry matter (tons/ha)
14 April	10.1	10.0	1 April	5.5	10.8
28 April	9.1	9.3	15 April	2.3	9.2
12 May	3.5	9.1	29 April	1.3	8.8
26 May	2.2	7.0	13 May	0.6	7.1
No N applied	3.4	5.3	No N applied	0.6	2.6
LSD (0.05)	2.3	1.9		1.1	1.4
LSD (0.01)	3.1	2.6		1.5	1.9
2nd crop 1969 (cleaning cut 1 August, harvest 26 November)			2nd crop 1970 (cleaning cut 13 July, harvest 10 November)		
nitrogen (date)	yield of PGS (kg/ha)	yield of dry matter (tons/ha)	nitrogen (date)	yield of PGS (kg/ha)	yield of dry matter (tons/ha)
2 August	6.0	6.0	14 July	15.3	10.0
23 August	2.4	4.9	28 July	20.2	10.6
13 September	2.4	4.3	11 August	7.3	9.4
4 October	1.8	4.1	25 August	–	–
No N applied	–	2.3	No N applied	–	–
LSD (0.05)	1.6	1.0		7.4	NS
LSD (0.01)	2.2	1.4		10.7	NS

NS = not significant.

of dry matter (Table 3) and head numbers (Table 4) also decreased progressively, but to a much lesser extent. Seed yields were generally much higher in 1971 than in 1970 and 1969.

Table 5 shows that late applied N increased the number of non-heading tillers at the advanced stages of growth, when compared with early applied N and no-N. The decline in numbers was most pronounced in the case of early applied N.

In the late-season crops, yields of PGS and dry matter were higher at T_1 in 1969 only (Table 3). In 1970 and 1971, yield of PGS and dry matter as well as yield of clean seed, percentage PGS and head number were highest when N was applied 2 weeks after the cleaning cut. Unlike the early-season crops, the late-season crops produced IHE and shedding earlier with early N application (Table 4). This increase in shedding may have decreased PGS yield at T_1.

Discussion

It is evident that split application was disadvantageous (Exp. 1), that cleaning cut and subsequent top dressing should be carried out early in the rainy season (Exp. 2) and that top dressing should follow soon after the cleaning cut (Exp. 3 and 4). A delay of 4

Table 4. The effect of delayed nitrogen application on seed crops of Nandi II, 1971. Experiment 4. (First crop harvested on 23 July, followed by a cleaning cut on 7 August. Second crop harvested on 22 December).

Date of nitrogen application	Head number per m² at IHE	Yield of clean seed (kg/ha)	PGS (%)	Yield of PGS (kg/ha)	Head number per m² at harvest	1000-grain weight (mg)	Seed shedding (1-5; 5 = no shedding)
First crop							
5 April	4.4	151	47	71	310	610	NR
19 April	4.6	113	34	38	280	580	
26 April	5.0	77	35	27	270	580	
3 May	4.3	60	32	19	220	600	
10 May	7.1	59	36	21	200	600	
LSD (0.05)	NS	24		15	40	NS	
LSD (0.01)	NS	33		21	50	NS	
Second crop							
13 August	NR	63	37	23	210	630	4.0
20 August		88	48	42	260	610	4.2
27 August		100	50	50	250	620	4.3
3 September		89	45	40	240	620	4.6
10 September		68	46	31	200	600	4.6
LSD (0.05)		20		5	40	NS	0.4
LSD (0.01)		29		7	60	NS	0.6

NS = not significant; NR = no record taken.

Table 5. The effect of nitrogen application on numbers of non-heading tillers; 1969, 1st crop, cleaning cut 14 April, IHE 13 June, harvest 1 August. Experiment 3.

Nitrogen applied (date)	Number of non-heading tillers per m²			
	30 April	13 June	11 July	1 August
14 April	2020	1040	430	250
26 May	2010	1200	1200	620
No N applied	1770	1190	870	430
LSD (0.05)	NS	NS	200	250
LSD (0.01)	NS	NS	280	NS

NS = not significant.

weeks in cleaning cut and/or top dressing reduced PGS yield by more than 60 % (Tables 2, 3 and 4). Additional advantages of an early first crop are the higher yields of dry matter (Table 2 and 3), the reduced incidence of bunt *(Tilletia echinosperma)* and the ample time left for utilizing the herbage before top dressing is required for the second crop.

The response to N was largely governed by season, but stage of growth limited the effect of season. N, when applied 6 weeks after the cleaning cut, produced no more than the no-N treatment (Table 3). Table 5 showed that late applied N increased the number of non-heading tillers at advanced stages of growth and, presumably, also the number of late heading tillers. If this is accepted, it becomes clear why head numbers were very much the same in the single and split application of Table 1 and also why heads were on avarage shorter in the split application. PGS yields were however lower with late applied N, probably because late heads are likely to develop at the expense of seed maturation in early heads without compensating for the latter. There was no evidence that late N increased 1000-grain weight. In *Paspalum plicatulum,* Chadhokar and Humphreys (1970) observed that seed production was independent of N nutrition after head emergence.

In a recent study of a seed yield experiment on *Setaria sphacelata,* involving various varieties, N levels, harvest dates and row widths, Hacker and Jones (1971) also reported a slight, albeit not significant, reduction in yield of clean seed from split application. N, varying from 42 to 336 kg per ha applied in 2 equal dressings per year, resulted in yields of clean seed varying on average from 14 to 28 kg per crop with an apparently linear response. The interpretation of these yields, though low in comparison with those obtained at Kitale, is complicated in that study by the absence of data on PGS percentage, the most unpredictable yield aspect of tropical grasses.

In the late-season crops, a delay of not more than 2 weeks gave the best PGS yields in all 3 experiments of 1970 and 1971. This shows that, although season is important, its effect is reduced if N is applied at an advanced growth stage. Management may have an effect also. In the late-season crops of 1970, yields were highest in Exp. 2 in the harvest, cut and top-dressed on 16 July, and in Exp. 3 in the treatment cut on 13 July and top-dressed on 28 July; the harvest top-dressed on the day after the cleaning cut was high also. Apparently, cleaning cuts earlier or later than mid-July were reducing seed yield.

It is of interest to note that delay in date of cleaning cut or date of top dressing gave similar crop responses. Since treatments had a far more dramatic effect on PGS yield than on head number and 1000-grain weight, seed setting was the component affected most. On the other hand, date of IHE was the same in the early-season crop irrespective of date of top dressing, so that heading and flowering occurred under the same weather conditions whether N had been applied early or not. Consequently, seed setting was determined at some stage before heading, weather conditions during flowering having little, if any, effect on the differences observed.

The obvious importance of applying N to young grass at the onset of the rains can perhaps be explained with some climatic data at hand. Rainfall normally reaches a peak in April-May (Boonman, 1972) and temperatures and solar radiation both drop by about 10 % until they begin rising again after July. Growing conditions may, therefore, be more favourable at the onset of the rains. This is similar to the experience obtained with maize in Western Kenya (Allan, 1972) and other crops in the tropics (MacDonald, 1968). Allan found that each week of delay in maize planting resulted on average in a drop of 650 kg per ha and grain yields were reduced by half if maize planting was delayed 6 weeks.

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